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DESCRIPTION OF THREE NEW *TRICHOGRAMMA* (HYMENOPTERA: TRICHOGRAMMATIDAE) FROM NEW ZEALAND AND THEIR RELATIONSHIP TO NEW WORLD SPECIES

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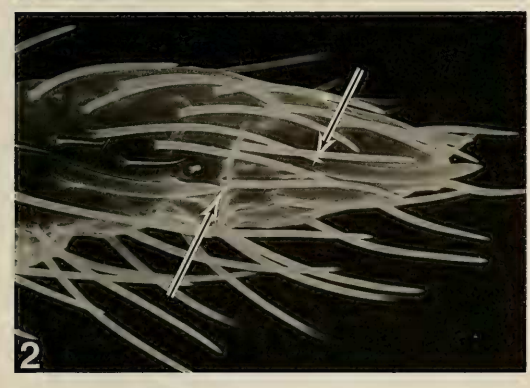
Abstract.—Three new species of *Trichogramma* are described from New Zealand: ***T. maori, T. valentinei*** and ***T. falx***. These species are the only known representatives of the cosmopolitan nominate subgenus known to occur in New Zealand. This assemblage represents a monophyletic group with closest relationship to New World species of the Drepanophorum Group. A key separating the three New Zealand species is included.

Key Words: Trichogrammatidae, *Trichogramma,* New Zealand

A recent examination of a collection of undetermined New Zealand *Trichogramma* has revealed three undescribed species. All are members of the nominate subgenus, and represent a group of remarkably distinct forms with closest ties to certain New World species. These descriptions represent the first *Trichogramma* known only from New Zealand. Noyes and Valentine (1989), in their review of New Zealand Trichogrammatidae, noted the presence of the Australian species, *T. funiculatum* Carver of the subgenus *Trichogrammanza,* and several "undetermined, mostly probably undescribed species." The descriptions below are based on a collection of card mounted specimens received from the New Zealand Arthropod Collection in Auckland which included the material examined by Noyes and Valentine. The majority of this material was collected by sweeping and Malaise trapping in relatively natural areas. Representatives of both sexes from all series were mounted in Canada balsam on slides.

The terminology associated with the male genitalia and used in the descriptions below was reviewed by Pinto (1992). Complete terms with acronyms are incorporated into the first description; their first mention is indicated in bold. The other descriptions employ the acronyms only. Important terms also are indicated in Figures 5–15. The apical distance (AD) and basal distance (BD) associated with the genital capsule require some explanation. AD refers to the distance from the apex of the parameres to the base of the intervolsellar process. BD is the distance from the base of the intervolsellar process to the base of the genital capsule. Both measures are often presented as a proportion of the total length of the genital capsule (GL). The intervolsellar process, volsellae and dorsal lamina extend within the apical distance and their length is reported in relation to it. Terminology associated with the forewings follows Doutt and Viggiani (1968) (see their Fig. 1). The number of setae between the 4th and 5th tracks on the forewing provides a relative measure of setal density. The 4th is the first setal track posterior to the RS_2; the 5th is the track immediately anterior to the r-m.

All New Zealand localities are followed by a 2-letter code referring to arbitrarily derived geographic areas as given in Crosby



Figs. 1–2. Male antenna, *Trichogramma valentinei.* 1, (230x). 2, Apex of flagellum (lateral view, 610x); arrows showing the pronounced separation of the two placoid sensilla (left arrow at apex of basal placoid sensillum, right arrow at base of apical placoid sensillum).

et al. (1976). Abbreviated collecting methods in the records section include SP (= sweeping) and MT (= Malaise trap).

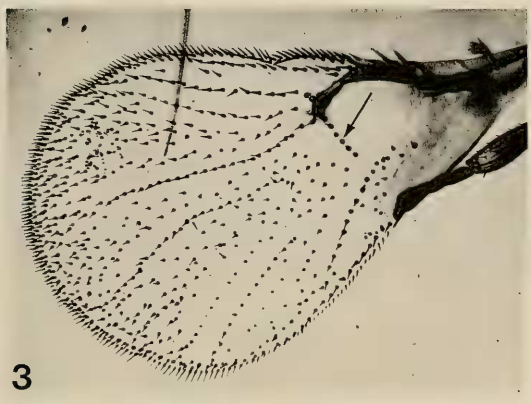
Trichogramma maori Pinto and Oatman, New Species

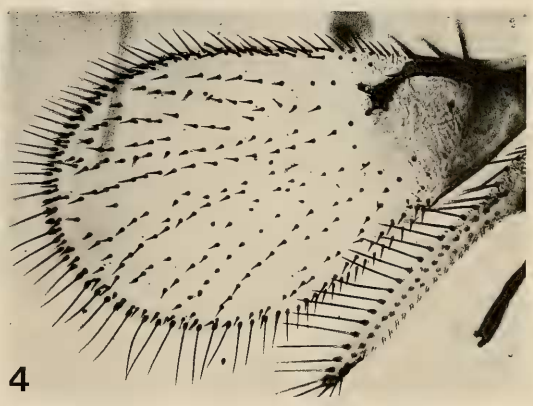
(Figs. 3, 5–8, 16)

Diagnosis. *Trichogramma maori* resembles the other two species described here as well as several other, primarily North American, species as follows: dorsal lamina of male genital capsule with posterior extension enlarged, concealing parameres and volsellae in dorsal view; parameres ventromedial to volsellae; volsellae strongly curved; dorsal ridge well developed. It is separated from these species by its broad forewings (ca. 0.4 mm wide), the very short fringe setae on the forewings (length <0.10 maximum wing width), the spiniform, bifid intervolsellar process, and the broad and apically subrhomboidal aedeagus (see Fig. 6).

Description. Based on slide and card-mounted material. Quantitative data reported as means ± S.D. or as ranges, taken from 3 males (hind tibial length [**HTL**] = 0.25 mm) and 3 females (HTL = 0.25–0.26 mm).

Color dark brown except head dusky yellow brown above and legs considerably lighter. Relatively large and robust, length





Figs. 3–4. Forewings. 3, *Trichogramma maori,* arrow pointing to RS_1 setal track. 4, *T. valentinei.*

(from slide-mounted specimens) 0.7–0.8 mm.

Forewing (Fig. 3) very broad, 0.42 ± 0.01 mm wide, 0.57 ± 0.01 as wide as long, setal tracks distinct, with 50–70 setae between 4th and 5th tracks; RS_1 well indicated, consisting of ca. 6 distinct setae; longest fringe setae at posterolateral corner of wing very short, their length less than 0.10 maximum wing width. Hind wing relatively broad with anterior and posterior tracks complete, both approaching apex of wing, usually with 1–2 setae between middle and posterior tracks near middle of wing. Anterior scutellar setae elongate, 0.6–0.8 length of posterior pair.

Male. Antenna (as in Fig. 1) with flagellum relatively short for body size, ca. 0.18 mm, 5.1 ± 0.03 as long as basal width (**FL/BFW**), 0.72 ± 0.01 as long as hind tibia (**FL/HTL**), 1.52 ± 0.03 length of scape (**FL/SL**); setae on flagellum relatively short, ratio of the length of the longest setae to the basal width of the flagellum (**FSL/BFW**) = 1.77 ± 0.17 (1.7–2.0); basiconic peg sensilla (**BCPS**) relatively small, subglobose apically, formula 1-1-1-0-1-1; several short, unsocketed setae scattered on ventral surface.

Genital capsule (**GC**) (Figs. 5–8) relatively broad with posterior extension of the dorsal lamina (**DLA**) broad and elongate, concealing intervolsellar process (**IVP**), volsellae (**VS**) and parameres (**PM**) in dorsal view; base of VS distinctly lateral to PM. Ratio of genital width to length (**GW/GL**) = 0.46 ± 0.02, distinctly narrower in posterior half; ratio of the apical distance to genital length (**AD/GL**) = 0.29 ± 0.01; length of the dorsal aperature (**DAL**) ca. 0.7 GL; DLA arising slightly posterior of middle of GC, its length ca. 0.4 GL; posterior extension of DLA distinctly constricted at base, sides convergent apically, posterior margin broadly rounded, extending beyond apex of PM, occupying ca. 1.3 AD; PM relatively narrow, convergent from base to apical ⅔, then slightly divergent to apex, relatively blunt apically; VS distinctly broader than PM in ventral view, strongly curved: curved anteriorly from base, then extending posteroventrally with apex attaining ca. 0.7 AD, medial surface sparsely hispid, spine of VS directed ventrally; IVP bispinose (Fig. 7), attaining ca. 0.3 AD; ventral processes (**VP**) not obvious, very small, on base of IVP; ventral ridge (**VR**) distinct, narrow, extending from IVP to ca. 0.5 basal distance (**BD**); dorsal ridge (**DR**) moderately well developed, extending from base to at least middle of GC. Aedeagus unique, apical half subrhomboidal and distinctly curved ventrally (Figs. 6, 8); relatively short but very broad; greatest width ca. 0.8 maximum width of DLA; aedeagus length (**AL**) = 0.9 GL, 0.71 ± 0.03 HTL; apodemes convergent anteriorly, their length at least 0.5 AL (posterior limits not easily discerned with light microscope).

Female.—Antenna with 1 BCPS at apex of first and second funicular segment; ovipositor relatively short, ratio of ovipositor length to hind tibial length (**OL/HTL**) = 0.70 ± 0.02.

Types: Holotype male. NEW ZEALAND. Banks Peninsula (MC), Prices Valley; x-1980; "Malaise trap, edge of native bush"; R. Macfarlane. Allotype female. Same data as holotype except collected xi-1980; both deposited in the New Zealand Arthropod Collection (NZAC); Auckland, New Zealand. Three male and 2 female paratypes (same data as holotype) deposited in NZAC and UC Riverside.

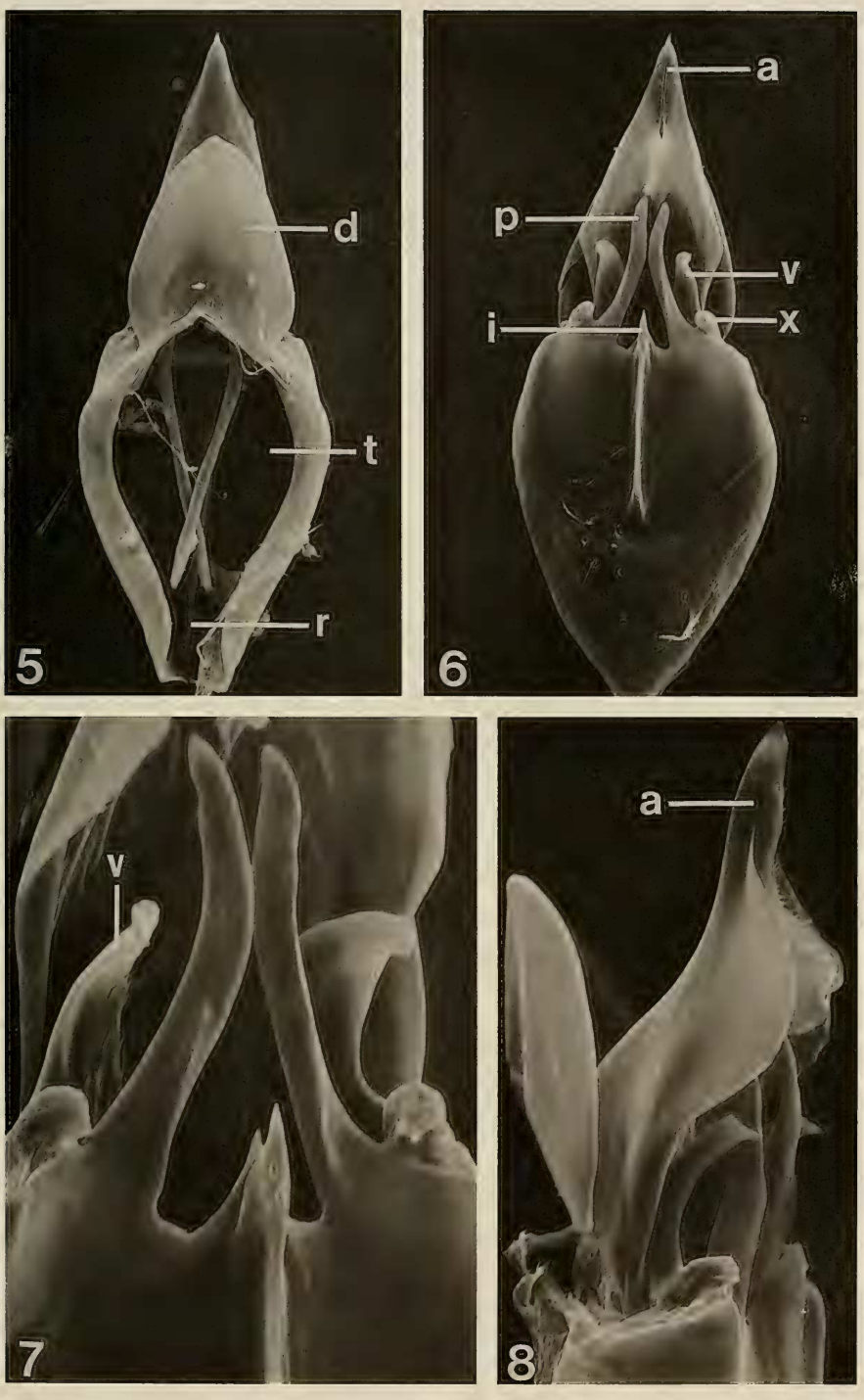
Etymology: Named for the Maori, the native people of New Zealand.

Hosts: This species has been reared from eggs of *Eutorna* sp. (Oecophoridae) and *Graphania* sp. (Noctuidae).

Geographic distribution. Fig. 16. New Zealand: North and South islands.

Material examined. 57 males and females on slides and on cards or in capsules (air dried).

Records. **New Zealand.** Auckland (AK); "*Eutorna* eggs on boysenberry"; 19 females. Banks Peninsula (Prices Valley) (MC); x-80; MT "edge of native bush"; 7



Figs. 5–8. *Trichogramma maori*, male genitalia (posterior end at top). 5, Dorsal view (408x). 6, Ventral view (460x). 7, Ventral view with 30 deg. tilt showing bispinose nature of the intervolsellar process, and hispid volsellae (1530x). 8, Lateral view showing ventral curvature of aedeagus (800x). a = aedeagus, d = dorsal lamina, i = intervolsellar process, p = paramere, r = dorsal ridge, t = dorsal aperature, v = volsella, x = base of volsella.

males, 5 females; R. Macfarlane. Birkenhead (AK); i-81; MT "in second growth bush"; 2 males; J. Longworth. Bullock Creek (WD); ii-26/iii-1-93; MT "edge *Nothofagus* forest"; 1 male; L. LeSage. Bullock Creek (WD); ii-26-93; SP "vegtn. edge of forest"; 5 females; L. LeSage. Cobb Reservoir (NN); xii-80; MT; 1 male; A. Curtis. Kinloch S(tate) F(orest), Dart R(iver) (OL); i-81; SP "*Nothofagus* for., broadleaf, grass, *P. totara*"; 1 female; J. Noyes/E. Valentine. Kongahu (NN); i-81; MT "nr swamp"; 1 female; J. Jones. Lake Rotoiti (BR); ii-⅘-78; MT; 2 males, 3 females; S./J. Peck. Makarora West (S of Nat. Pk.) (OL); i-18-81; SP *Nothofagus* forest; 1 male, 1 female; J. Noyes/E. Valentine. Lynfield (AK); xii-80; 1 male; G. Kuschel. Pigeon Hill (WD); ii-24-93; "beating broadleafed podocarp forest"; 1 female; L. LeSage. Pleasant Flat (WD); iii-6-93; SP "weeds & trees on rd"; 1 male; L. LeSage. Roaring Meg (CO); i-13-81; SP "tussock grasses, *Discaria, Rosa, Juncus, Pimela*"; 1 male; J. Noyes/E. Valentine. Te Puke (BP); xi-7-87; ex. *Graphania* eggs; 1 male, 2 females; P. Stevens. Wainui Inlet (NN); ii-23-93; SP fls. *Daucus carotta*; 1 female; L. LeSage.

Notes: Several of the records above are based on females only. Although it is not possible to determine most species of *Trichogramma* with females, those of *T. maori* can be distinguished by the combination of color, body size, fore and hindwing features and the length of the mesoscutellar setae.

Trichogramma valentinei Pinto and Oatman, New Species

(Figs. 1, 2, 4, 9–11, 17)

Diagnosis.—Distinguished from *T. maori* by its considerably narrower forewings, the absence of the RS_1 setal track of the forewing in most specimens, its more strongly curved parameres and volsellae, the much narrower, subfiliform volsellae, the larger and somewhat clavate intervolsellar process, the much greater apical distance, and the narrower aedeagus. This species is very similar to *T. falx,* described below. It is separated by two traits associated with the flagellum of the male: the considerably shorter setae, and the size and position of the basal linear placoid sensilla. Also, the mesoscutellar setae are longer in *T. valentinei.*

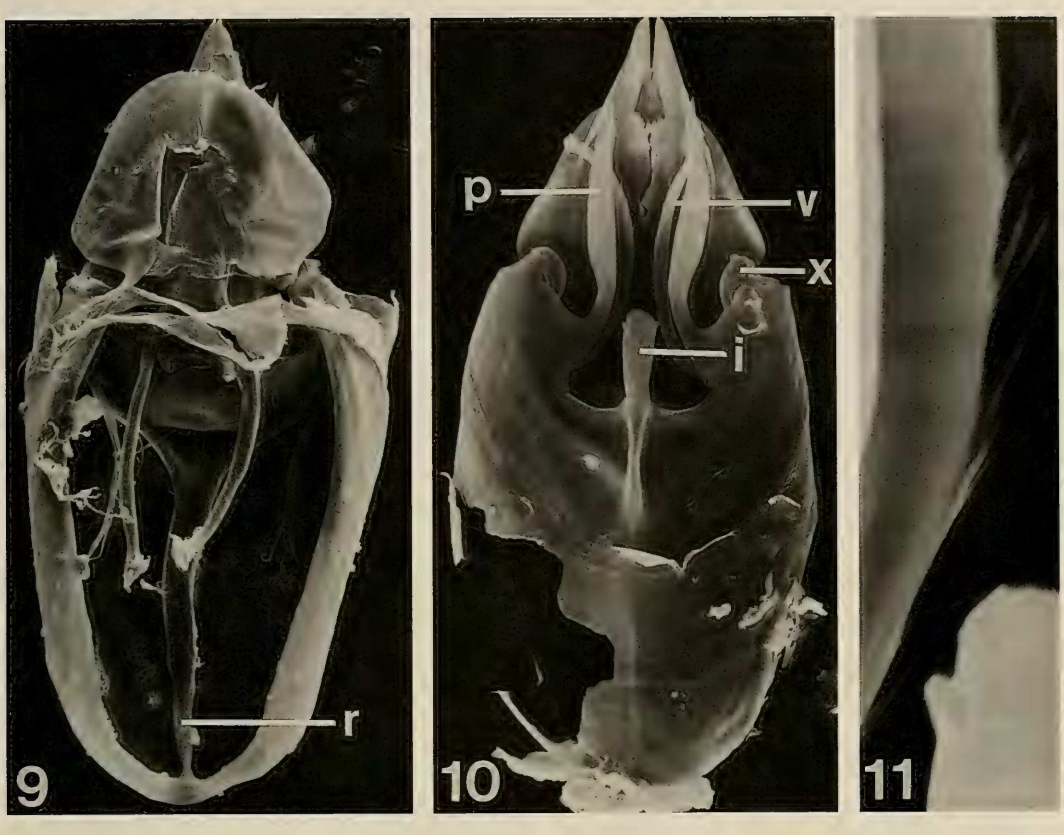
Description.—Based on 4 males and 5 females. Quantitative data taken from 2 males and 2 females (HTL = 0.20 mm for all specimens) and reported as a range unless invariant.

Color brown except head dark yellow above; relatively slender, elongate, length (from slide-mounted material) 0.7–0.8 mm.

Forewing (Fig. 4) relatively slender, 0.30–0.31 mm wide, 0.45–0.48 as wide as long, with 32–45 setae between 4th and 5th tracks; RS_1 usually absent; longest fringe setae at posterolateral corner of wing moderately long, their length 0.18–0.19 maximum wing width. Hind wing with anterior and posterior tracks short, each consisting of 4–5 setae which do not extend beyond half the distance from hamuli to wing apex. Anterior scutellar setae moderately long, 0.4–0.5 length of posterior pair.

Male.—Antenna (Fig. 1) with flagellum straight, relatively short and robust, ca. 0.16 mm long, 5.0–5.1 as long as wide, 0.79–0.81 as long as hind tibia, 1.7–1.8 scape length; flagellar setae short, robust, tapering abruptly at apex; FSL/BFW = 1.4–1.5; BCPS short, digitiform, formula 1-0-0-0-1-1; without unsocketed setae on ventral surface. Basal-most placoid sensillum relatively short, length ca. 1.2 BFW, its apical third extending above antennal surface, broadly separated from apical placoid sensillum on same (lateral) surface by a distance equal to ca. ⅔ its own length (Fig. 2).

Genital capsule (Figs. 9, 10) with DLA broad and elongate, concealing IVP, VS, and PM in dorsal view; insertion of VS distinctly lateral to PM. GW/GL = 0.42–0.46; apical distance very large, AD/GL = 0.44–0.47; DAL = 0.70 GL; DLA arising in posterior half of GC, its length ca. 0.4 GL; pos-



Figs. 9–11. *Trichogramma valentinei,* male genitalia (posterior end at top). 9, Dorsal view (630x). 10, Ventral view (570x). 11, Detail of left volsella showing hispid medial surface (4200x). i = intervolsellar process, p = paramere, r = dorsal ridge, v = volsella, x = base of volsella.

terior extension of DLA strongly constricted at base, extending beyond PM, occupying 1.1 AD; PM produced medially at base, then abruptly curving posteriorly, width increasing to middle from base, gradually tapering to apex; VS extremely elongate, narrow, subfiliform and curved, scythe shaped, attaining 0.9 AD, narrower than PM throughout entire length, curving strongly anteriorly from base, then broadly arcing posteriorly with at least medial surface hispid (Fig. 11), spine not distinct; the two VS converging at middle and diverging strongly apically; IVP inserted considerably anterior to base of PM and VS, sticklike in shape, subclavate, occupying ca. 0.4 AD; VP small, slightly protuberant, positioned near apex of IVP (Figs. 10, 11); VR poorly developed, occupying ca. 0.3 BD (not easily seen with light microscope); DR very well developed, apparently extending entire BD, bifurcating just anterior to intervolsellar bridge area with an arm extending anterolaterally to base of each VS (Fig. 9). Aedeagus relatively short, its length 0.56–0.57 HTL and 0.73–0.76 GL; moderately broad, ca. 0.5 maximum width of posterior extension of DLA, subconical apically, tapering noticably to a distinct point; apodemes comprising ca. 0.4 AL.

Female.—Antenna with funicular segments subquadrate; BCPS at apex of F1, absent from F2. Ovipositor 0.69–0.75 HTL.

Types: Holotype male. NEW ZEALAND. Cobb Ridge (Sth) (NN), 1100 m; xii-3-1980; "native tussock grassland"; J. Noyes/E. Valentine/A. Walker. Allotype female. Data as for holotype. Types deposited

in NZAC. Three male and 2 female paratypes with same data as holotype in NZAC and UC Riverside.

Etymology: Named after the New Zealand entomologist, Dr. E. W. Valentine.

Variation: A short RS_1 setal track, consisting of 3 setae, is present in one specimen from the type locality.

Geographic distribution. Fig. 17. New Zealand: known from a single locale on South Island.

Material examined: 10 males and females on slides and on cards (air dried).

Records: **New Zealand.** Cobb Ridge (NN) (see type information); 5 males, 5 females.

Trichogramma falx Pinto and Oatman, New Species
(Fig. 17)

Diagnosis.—This species is very closely related to *Trichogramma valentinei.* It is separated by differences in male antennal features, and length of the mesoscutellar setae (see below).

Description.—Based on 5 males and 1 female. Quantitative data taken from 3 males (HTL = 0.15–0.17 mm) and 1 female (HTL = 0.17 mm), and represented by means ± S.D. or ranges.

As in *T. valentinei* except as follows: Anterior mesoscutellar setae shorter, minute, no more than 0.1 the length of posterior pair. *Male.* Antenna with flagellum with longer, less robust setae, FSL/BFW = 2.38 ± 0.2 (2.2–2.6); basal placoid sensillum longer, its length ca. 1.6 BFW, with, at most, apical $^1/_5$ of sensillum extending above antennal surface, its apex attaining base of apical placoid sensillum on same (lateral) surface; with a few short unsocketed setae on ventral surface of basal half of flagellum.

Other descriptive features as follows: Color brown; body length ca. 0.6 mm. Forewing relatively narrow, 0.23–0.26 mm wide, FWW/FWL = 0.45 ± 0.01, with 24–26 setae between 4th and 5th tracks. RS_1 absent. Hind wing with 1–6 setae in both anterior and posterior tracks. *Male.* Antenna: FL/BFW = 5.02 ± 0.26; FL/SL = 1.73 ± 0.08; FL/HTL = 0.93 ± 0.01. Genital capsule: GW/GL = 0.47 ± 0.04; AD/GL = 0.47 ± 0.03; DLA occupying 1.1 AD; VS and IVP attaining ca. 0.9 and 0.4 AD, respectively. Aedeagus length 0.61 ± 0.02 HTL, 0.80 GL. *Female.* Ovipositor length 0.85 HTL.

Types: Holotype male. NEW ZEALAND. St. Arnaud (BR), 600 m; xii-9-1980; "native grassland/sphagnum bog"; J. Noyes/E. Valentine/A. Walker; deposited in NZAC. Three male paratypes, same data as type, deposited in NZAC and UC Riverside.

Etymology: Falx: Latin for sickle; in reference to the shape of the volsellae in this species.

Geographic distribution: Fig. 17. New Zealand: South Island.

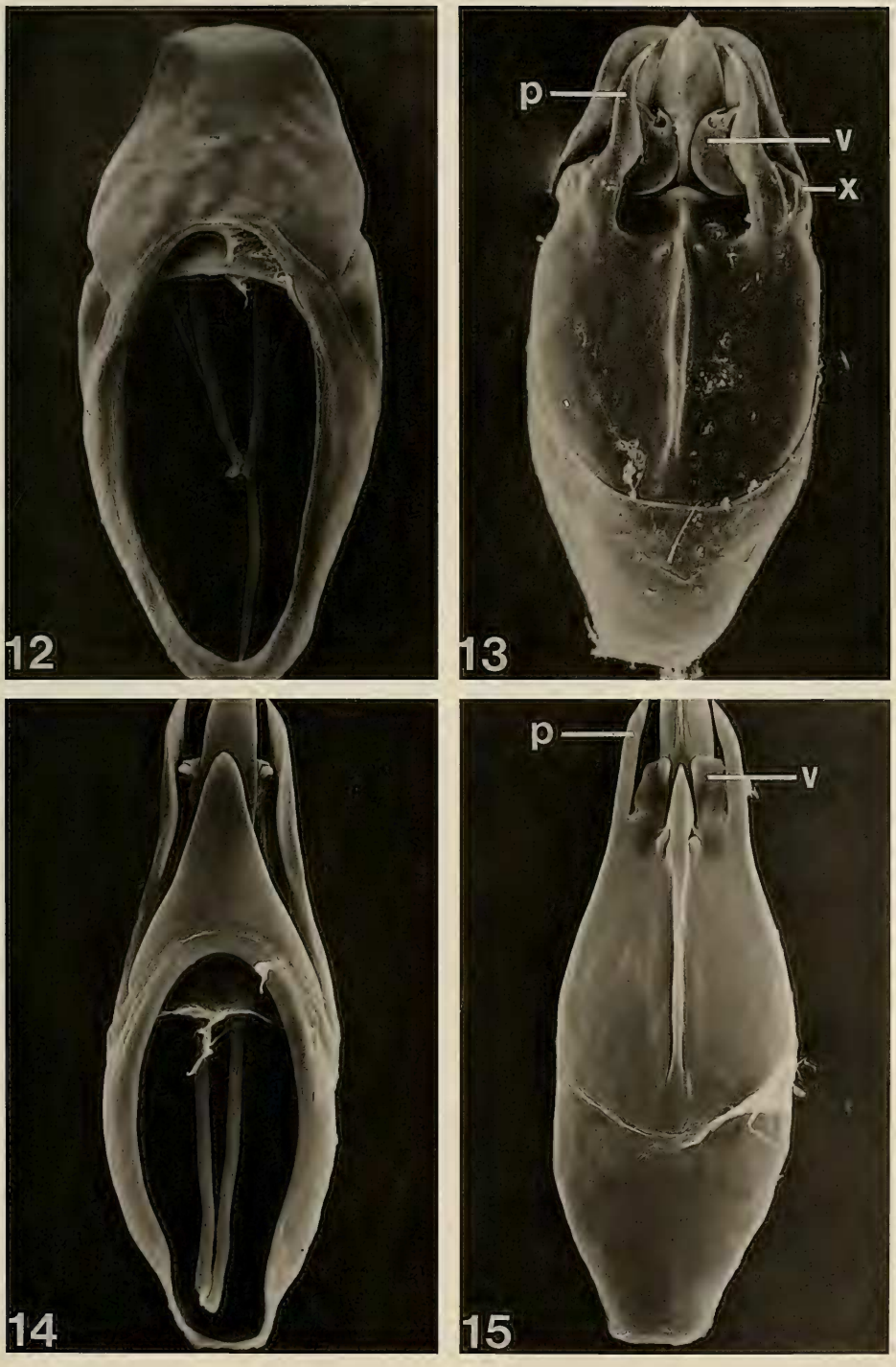
Material examined: Six males and females, all on slides.

Records: **New Zealand.** Cromwell Beetle Res., Cemetary Rd (CO); xi-17-77; "litter"; 1 male, 1 female; J. Watt. St. Arnaud (BR), see type information; 4 males.

Notes: The absence of the RS_1 setal track is unique to *T. valentinei* and *T. falx.* The presence of this line of setae is one of the characters commonly used to distinguish *Trichogramma* from *Trichogrammatoidea* (Pinto and Stouthamer 1994). It's absence in these species is almost certainly a reversal considering the presence of all other wing and genitalic features defining *Trichogramma,* intraspecific variation of this trait in *T. valentinei,* as well as the derived nature of the genitalia in both species. The antennal differences separating *T. falx* from *T. valentinei* are consistent with species differences separating other closely related *Trichogramma,* such as *T. minutum* and *T. exiguum* in North America (Pinto et al. 1983).

Discussion

The three new *Trichogramma* appear to represent a monophyletic assemblage of



Figs. 12–15. *Trichogramma* genitalia (posterior end at top). 12–13, North American *T.* sp. a of *Drepanophorum* Group: 12, Dorsal (770x). 13, Ventral (700x). 14–15. *T. semblidis:* 14, Dorsal (700x). 15, Ventral (640x). p = paramere, v = volsella, x = base of volsella.

Figs. 16–17. Distribution of *Trichogramma* spp. in New Zealand. 16, *T. maori.* 17, *T. valentinei* (triangle); *T. falx* (dots).

species. Their closest ties are to the Drepanophorum Group of North America to which they are tentatively assigned. This group includes *T. drepanophorum,* described by Pinto & Oatman (1985), and at least two undescribed species (= *T.* sp. a, *T.* sp. b). All occur in the eastern United States; the male genitalia of *T.* sp. a are shown in Figs. 12, 13. This species group is characterized by the following derived traits: 1) posterior extension of the dorsal lamina greatly enlarged and concealing parameres and volsellae dorsally; 2) floor of dorsal aperture with a well-defined dorsal ridge, 3) base of parameres medial to that of volsellae, 4) volsellae strongly curved. The plesiomorphic condition for these features, found in most *Trichogramma,* can be illustrated by the Holarctic species *T. semblidis* (Figs 14, 15) where the posterior extension is considerably narrower and linguiform, the dorsal ridge is absent, the parameres are lateral to the volsellae, and the volsellae are straight or only slightly curved. Interestingly, a bifid intervolsellar process as in *T. maori* (Fig. 7) also occurs in *T.* sp. b of the Drepanophorum Group.

The limits of the Drepanophorum Group are currently being investigated as part of a revision of North American *Trichogramma* (Pinto, in prep.), and several additional forms possessing one or more of its defining features may ultimately be assigned. The geographic distance of North American members of the group from those in New Zealand may be an artifact of sampling considering the virtual absence of collections from South America especially in the southern, temperate regions of the continent.

The monophyly of the New Zealand species is not immediately obvious. In fact *T. maori* is not noticeably more similar to its New Zealand congeners than to the North American *T.* sp. a. The phenetic distance is roughly similar in both directions. The structure of the volsellae, however, suggests that the three New Zealand species do represent a monophyletic assemblage. In all three species the volsellae curve anteriorly

from their base and the medial surface is hispid. These traits are not known to occur in any other species of *Trichogramma.*

The three species described here are the only known New Zealand representatives of the speciose subgenus *Trichogramma.* Although four species of this cosmopolitan group were introduced to the country from other parts of the world for biological control, these apparently have not become established (Cameron and Allan 1989), and none occurred in the collection examined for this study. The neighboring Australian *Trichogramma* fauna is represented by several species of the nominate subgenus as well as three species of the subgenus *Trichogrammanza* (Oatman and Pinto 1987). Australian representatives of the former group reflect Asian affinities however (Pinto and Stouthamer 1994) and none has yet been recorded from New Zealand. The Drepanophorum Group is not known to occur in Australia. *Trichogrammanza,* on the other hand, is restricted to Australia and New Zealand, and the same or very similar species occur in both countries. Thus, the known *Trichogramma* of New Zealand include only four named species: *T. maori, T. valentinei, T. falx,* and *T.* (*Trichogrammanza*) *funiculatum.* The nominate species are related to a New World element; the *Trichogrammanza* are closely tied to Australia.

It should be mentioned that Noyes and Valentine (1989) estimated at least 15 undetermined species of New Zealand *Trichogramma* in addition to *T. funiculatum.* This estimate was based on a collection of card mounted specimens that we also examined for this study. Separation of *Trichogramma* to species is virtually impossible unless specimens are mounted on slides, and Noyes and Valentine appear to have overestimated the diversity of their collection. This material includes no more than eight species: the three described above, one or, at most, two very similar *Trichogrammanza* (including *T. funiculatum*), and two or three additional new species closely related to *T. valentinei* and *T. falx.* Unfortunately, the latter are represented by limited material that cannot adequately be described at this time. Included here are two specimens of a wingless form taken on Auckland Island at 150°, 32′ S latitude, a collection representing the southernmost record for the genus.

Key to the New Zealand Species of the Drepanophorum Group of *Trichogramma*

1. Male genitalia as in Figs. 5, 6 with intervolsellar process (IVP) spinelike; IVP originating at approximately same level as parameres. Forewing (Fig. 3) broad, with a distinct RS_1 setal track and a short setal fringe, length of longest setae in fringe less than 0.1 maximum wing length . . . . . *T. maori*

1′. Male genitalia as in Figs. 9, 10, with intervolsellar process (IVP) subclavate; IVP originating distinctly anterior to parameres. Forewing (Fig. 4) much narrower, usually without a distinct RS_1 setal track and with a much longer setal fringe, length of longest setae in fringe 0.15–0.20 maximum wing length 2

2. Male flagellum (Fig. 1) with setae short and robust, the length of longest setae ca. 1.5 basal width of flagellum; lateral surface with basal-most placoid sensillum widely separated from apical placoid sensillum (Fig. 2) . . . *T. valentinei*

2′. Male flagellum with longer, more slender setae, the length of longest setae at least twice the basal width of flagellum; lateral surface with basal-most placoid sensillum attaining base of apical placoid sensillum . . . . . *T. falx*

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